2-10-2011

Restoring Native Oysters in Great Bay Estuary, NH (2011)

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Final Report to the Piscataqua Region Estuaries Partnership

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Executive Summary

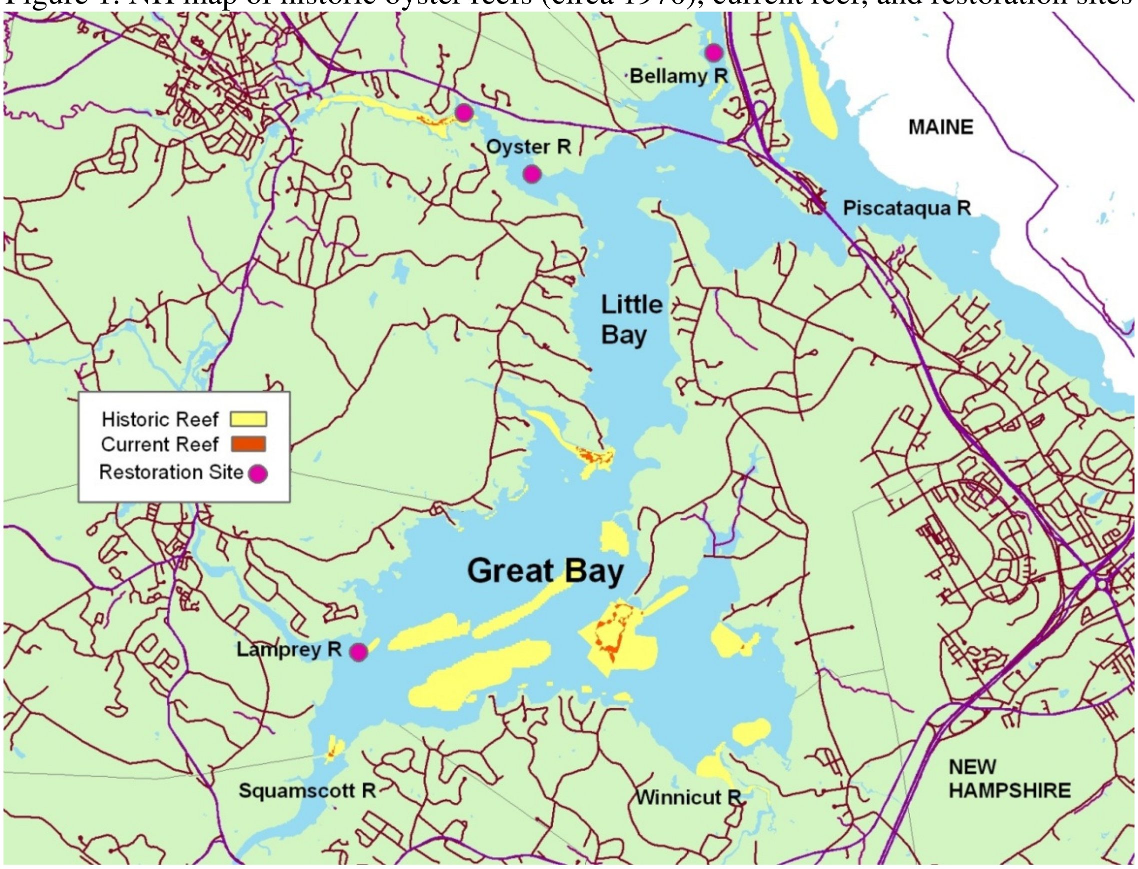
The eastern oyster (*Crassostrea virginica*) in New Hampshire's Great Bay Estuary has declined in the past decades, with local populations at very low densities due primarily to disease, excessive siltation, and past over-harvest. The loss of filtering oysters results in diminished ecological benefits for water quality, nitrogen control, and other services that healthy oyster populations provide. In support of regional management objectives to restore millions of oysters to the estuary, the Nature Conservancy (TNC) and the University of New Hampshire (UNH) piloted and scaled-up methods to successfully rebuild oyster reefs. Based on pilot results in 2009, we developed a technique using a thin layer of recycled clamshell "planted" over silted channel bottom as a hard substrate foundation to recruit natural spawn, supplemented with hatchery-raised and volunteer-grown seed "spat". In 2010, a full acre reef was constructed and seeded at the mouth of the Oyster River in Durham, producing a one-year standing stock of >200K oysters.

In 2011, restoration efforts were scaled up significantly, led by support from the Piscataqua Region Estuaries Partnership (PREP), with two acres of reef construction at the mouth of the Lamprey River (Newmarket NH). In June 2011, approximately 200 yd^3 of seasoned surf clam shell was deployed at the site for total shell coverage of 80,000 ft^2 (7,432 m^2). Fall monitoring results showed that an estimated 58K oyster spat were recruited to the reef (19.5 spat/m^2). Supplements from UNH remote setting operations added 428K spat to the reef areas, plus an additional 17K spat were raised by community volunteers. By fall 2011, the completed reefs achieved a standing stock of >500K oysters. In addition, another half-acre restoration site was built nearby with farmer support. Collectively, our efforts demonstrate significant progress towards a regional goal of 20 acres of oyster reef restored by 2020, and position us for further expansion of restoration work going forward.

Background

The growing problems with excess nutrients, wastewater and siltation in Great Bay require a multi-faceted response that includes improved point and nonpoint source controls, stronger advocacy for estuary protection policies, accelerated coastal land conservation, and innovative in-the-water control strategies. An important step in our recovery process is acknowledgement of the Eastern Oyster (*Crassostrea virginica*) and its role in our system. Healthy oyster populations provide significant water quality benefits because of their ability to filter about 20 gallons of water per day. These resilient bivalves serve as the estuary's water purification system by filtering out nutrients and suspended solids. Oysters also aggregate into reefs which provide habitat and feeding grounds for estuarine fish and other invertebrates. Sustainable populations of oysters are a keystone for the health of the Great Bay Estuary. However, since the early 1970s, we have lost about 90% of local oysters due primarily to disease, excessive silt pollution, and past over-harvest (see Figure 1 for historic/present reef comparison). PREP and others now recognize that restoring oysters to Great Bay Estuary is one of the best direct actions we can take to improve water quality and the overall ecological health of the estuary. The 2010 PREP goal for oyster restoration is 20 acres rebuilt by the year 2020.

Figure 1. NH map of historic oyster reefs (circa 1970), current reef, and restoration sites



In 2009, TNC and UNH developed methods to restore oyster reefs by "planting" shell on silted channel bottom, using primarily surf clam shell (*Spisula solidissima)* acquired in bulk from a seafood processor. That June, we constructed a 0.203 acre (8,100 ft^2 or 752 m^2) shell reef with

20 yd^3 (~20 tons) of thinly-spread shell that was dried for six months at a local compost site. We built the pilot reef in an area closed to harvest as a future spawner sanctuary. Figure 2 provides an overview of all the steps involved in our NH oyster restoration process.

Reef monitoring in fall 2009 using $0.025m^2$ quadrat samples showed successful natural spat settlement on the clamshell foundation with an average first-year spat set of $31/m^2$. The reef in the deep river channel bottom had lowest sediment accumulation and highest spat density (~$60/m^2$). We returned to the reef in fall 2010 to assess a second year of spat set and survival. Results showed that the clamshell was capable of maintaining juveniles for a second season, although some attrition had taken place. Total live spat on clamshell averaged $20/m^2$ in fall 2010. However, this rate of settlement on clamshell still compared favorably with natural spatfall on existing oyster reefs in the system, which according to NH Fish and Game annual surveys reached only ~$10/m^2$ for both 2009 and 2010. To supplement our reef, we also contributed 3,028 juvenile oysters raised by homeowner volunteers in our NH Oyster Conservationist Program. We were unable to secure funds to monitor the pilot reef in 2011, so our last standing-stock estimate for the pilot Oyster River reef was 18,000 oysters.

Figure 2. Summary of the NH oyster restoration process

Lessons learned from the pilot reef led us directly to an expansion of the UNH hatchery operation. We quickly recognized that natural recruitment, even supplemented with volunteer-raised spat, was not adequate to rebuild oyster reefs at a pace that achieved estuary-scale improvements. Seed supplements were clearly needed to achieve oyster densities of about $50/m^2$

that we observed on the best areas of the few natural reefs remaining in the estuary. Seeded oysters also provided some protection from the parasitic diseases MSX and Dermo that persist in our local oysters by using disease-resistant hatchery strains.

In addition to hatchery seeding, we adjusted our approach to reef building by working exclusively in the channel bottom areas, rather than on the sloped banks and terraced mudflats of the intertidal areas. We observed that more consistent flows in the channel reduced the amount of fouling and sediment build-up on the reef, and likely provided a steady food source to individuals. Selection of areas closed to harvest was also recognized as an important element of the program. These spawner sanctuaries provide future benefits to all areas of the estuary, including reefs open to recreational harvest. As part of the reef siting process, our pilot effort also helped us understand and work within the regulatory framework for permitting and state approvals associated with oyster restoration.

In 2010, we constructed a 1.0 acre (40,000 ft^2 or 3,716 m^2) clamshell reef at the mouth of the Oyster River, about 1 mile downstream of the pilot reef. The reef is located on the north side of the river channel along the shore of Wagon Hill Park in Durham (Figure 3). Pre-construction underwater video monitoring conducted by UNH confirmed that the river channel was free of eelgrass prior to reef building. In late June, shell was moved in one-ton feed bags and deployed through the bottom bag chutes by a sweeping barge crane one bag at time to cover ~ 20' diameter circle per bag. We constructed the reef as five parallel rows of twenty bags each for a total grid of 100 ton-bags of clamshell.

Figure 3. Oyster River (Durham) showing created pilot reef (red) and Wagon Hill reef (yellow)

In summer 2010, UNH's Jackson Estuarine Laboratory (JEL) hatchery acquired 3 million disease-resistant oyster larvae from Muscongus Bay Aquaculture in Maine. Larvae were released in two large seawater tanks filled with cages of clean, recycled oyster shells. After "remote setting" to settle larvae on the shells, the cages were moved offshore to a JEL nursery raft for growing during the summer months. Fall sampling showed that an estimated 200,970 spat were grown on the raft. In October, the cages of spat were transported to the site and spread by hand evenly over the reef. Along with the hatchery spat, the 2010 NH Oyster Conservationist (OC) Program contributed 3,066 live spat from volunteer-raised sources.

In December, post-construction monitoring of the Oyster River reef to count live spat was done using a customized sampling device known as “patent tongs”. The device is held open with a latch that springs closed when it hits the bottom, collecting a $0.5m^2$ sample that is winched up to the surface. Patent tong sampling allowed us to reach deep channel beds, but it required a large vessel and substantial labor to collect and process the samples. Samples were limited, but showed that hatchery and volunteer raised spat were surviving on the reef. Natural spat recruitment on clamshell was observed but at a very low density of $1.5/m^2$ for a recruitment total of 5,574 spat. As with the pilot reef, we were unable to return to the reef for subsequent sampling in 2011. In total, the 2010 Oyster River reef had produced a last standing-stock estimate of 209,610 oysters.

In addition to the large grid reef, we also worked with a local oyster farmer to spread clam shell over a nearby rocky outcrop for enhanced natural set in the mouth of the Oyster River. This project was funded by the USDA Natural Resources Conservation Service. The shell was spread over an area of about 0.5 acres (1,858 m^2) as a restoration-only site (i.e., no harvest). There was no systematic sampling done in this area to determine settlement rates or survival.

In the context of our growing oyster restoration program, we proposed to scale up efforts significantly in 2011 with construction of 2 acres of reef in the Lamprey River at Newmarket. The current project describes the planning, work, and results associated with this oyster restoration program in 2011.

Project Goal, Objectives and Tasks

The project was submitted as one proposal but funded out as separate but related contracts with TNC and UNH. For reporting, combined project goals and objectives are as follows:

GOALS

The overall goal of the project is to increase vital ecosystem services provided by oysters (i.e., filtration capacity, nutrient sequestering, and fish habitat) using cost-effective and proven restoration techniques. In 2011, the University of New Hampshire and The Nature Conservancy significantly scale-up local reef construction by building two acres of oyster reef in the mouth of Lamprey River tributary (Newmarket NH).

RESTORATION OBJECTIVES

For this project, these specific objective targets are identified: 1) 2 acres of shell-planting area covered with a single-layer of surf clam shell, 2) average density of >20 spat/m^2 in first year of settlement from natural recruitment, and 3) deployment of 250,000 spat on shell per acre for seeding from UNH hatchery sources.

TASKS

1. Project staging
   Seven total truckloads of dried surf clamshell, each containing 33 cubic yards, will be acquired from Blount Seafood in RI and trucked to UNH Kingman farm for drying over the winter. Permit for shell planting from NH DES will be prepared and logistics arranged for shell transport contractors.

2. Pre-construction activities
   All necessary permits for hatchery operation and spat release will be acquired from NH Department of Fish and Game. A Quality Assurance Project Plan for pre- and post-restoration monitoring will be developed. Underwater video monitoring will be used to survey the two proposed restoration sites near Moody Point at the mouth of the Lamprey River.

3. Reef construction
   Dried shell will be bagged at Kingman Farm. Shell bags will be transported to pier site. Shell bags are off-loaded from transport trucks and moved to pier via forklift. Bags are then loaded by rented barge crew and ferried to the restoration site. Operators will deploy one bag of shell at a time to apply a single layer of shell on the bottom. A total of two acres will be covered with the shell.

4. Hatchery and post-construction monitoring operations
   To supplement each acre of reef, about 250,000 oyster spat-on-shell (each <10mm in size) will be produced using remote setting techniques at UNH Jackson Lab and moved out onto the reef in small clusters (0.75-1.00 m^2). Post-restoration monitoring will be conducted at the restoration sites. Measures will be made to determine extent of shell coverage on bottom from randomly-placed 0.25 m^2 transect samples using patent tongs to excavate reef material. Live oysters are counted and measured (shell height to nearest mm with calipers). All materials will be returned to the sampling area, with care taken to return live oysters and shell material intact.

Results

The following sections describe the specific elements of our work and results for permitting, pre-construction monitoring, reef construction, remote setting operations, oyster conservationist volunteer work, post-construction monitoring, and outreach aspects of the restoration program.

The Lamprey River channel was selected as the work area due to the existence of live oysters in the area and a past history of large reefs in the area (Figure 1). Figure 4 shows an aerial map of the site with the proposed locations for the constructed shell reefs. Figure 5 shows a similar view from a USGS map, also including channel depths. The reefs are about 100m apart, located in the east and west curves of the main river channel along the shore of Moody Point.

Figure 4. Lamprey River site with proposed shell reefs (East and West)

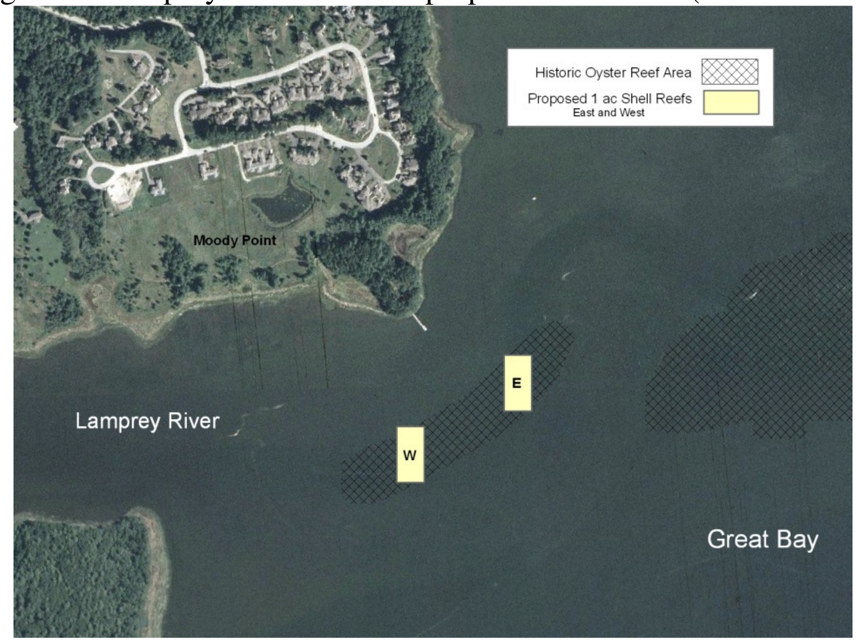
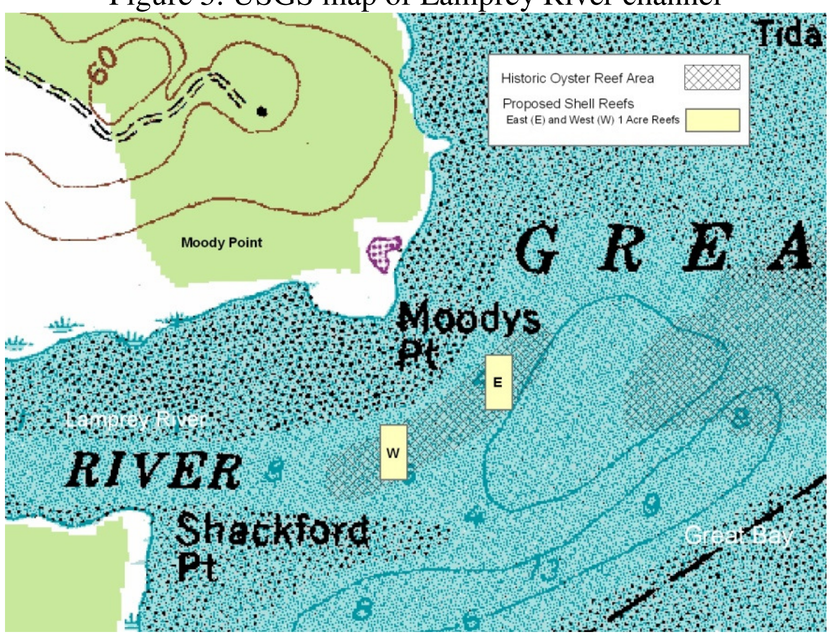


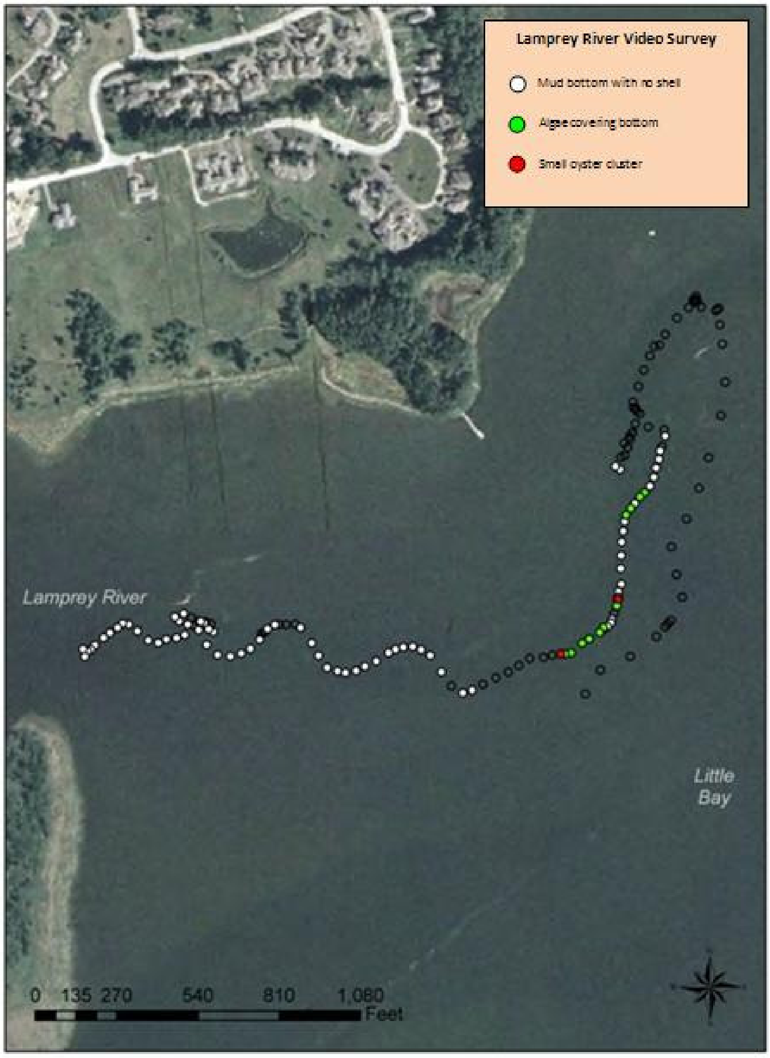
Figure 5. USGS map of Lamprey River channel



Project Staging (Task 1). In fall 2010 and early winter 2011, 200 yds^3 of seasoned clam shell, acquired in the fall of 2010 from the Blount Seafood processor in Warren RI and stored at UNH Kingman Farm for drying. TNC prepared and submitted two Wetlands Permit applications (one each for the East and West grid area). NH DES authorized the work as a single permit (2011-0036) received on 3-16-11.

Pre-Construction Activities (Task 2). In April 2011, UNH conducted video monitoring to assess channel bottom conditions, presence of scattered oyster shell and absence of eelgrass. Figure 6 shows the results of the video monitoring. Video results confirmed that the river channel areas proposed were free of eelgrass and included some scattered shell, indicative of suitable substrate and potential past presence of live oysters. Methods followed were as described in previous Quality Assurance Project Plans on file at Jackson Estuarine Laboratory.

Figure 6. Video monitoring at Lamprey River



Reef Construction Results (Task 3). In May and early June, TNC, UNH staff, and volunteers worked together to stage the shell for the reef construction, was loaded into one-ton weave feed bags for transport. We used a salt-and-sand spreader from UNH with a reversible conveyor belt, in combination with a front-end loader and a tractor forklift, to load the 200 bags (Figure 7). In early June, the bags were loaded onto flat-bed trailers and transported to the Pickering and Riverside Marine dock in Eliot Maine.

Between June 19 and June 24, the barge crew at Pickering Marine, along with TNC and UNH staff, constructed the reef. The shell bags were loaded onto a 150-ton barge and transported to the Lamprey River site in two separate trips. We constructed each 100 ft x 400 ft reef grid as twenty parallel rows with five bags in each row. The barge operator used a 70’ crane to lift each bag and working points from one side to the next to spread five bags across the bow (Figure 8). Then the operator would lift the spuds and slide back about 20' for the next row. The process was repeated twenty times for each grid block. Waypoints tracked by the barge crew showed that clamshell was spread over a total of 80,000 ft^2 (7,432 m^2) of channel bottom. *This result met our restoration objective for 2 acres of shell-planting area.*

Figure 7. Shell bagging equipment at Kingman Farm

Figure 8. Barge operator with crane spreading shell

Hatchery and post-construction monitoring operations (Task 4). In July 2011, the JEL oyster research lab acquired 6 million disease-resistant oyster larvae. Ray Grizzle and Krystin Ward used standard methods to remotely settle larvae onto recycled oyster shell, and to grow-out spat on the UNH nursery raft (Figure 9). Samples in the fall showed that an estimated 428,228 spat were grown on the raft for deployment on the restored reef. In October, spat were transported to the Lamprey site and spread by hand evenly over the reefs (Figure 10). In addition to hatchery spat, the 2011 volunteer Oyster Conservationist Program added 17,303 spat from 29 homeowners, our biggest community production ever. The OC program was funded from a separate program source in 2011. With 445,531 oysters on two acres, *we substantially met our restoration objective to seed 250,000 oysters per acre of construction.*

Figure 9. Krystin Ward and Ray Grizzle on nursery raft with spat-on-shell

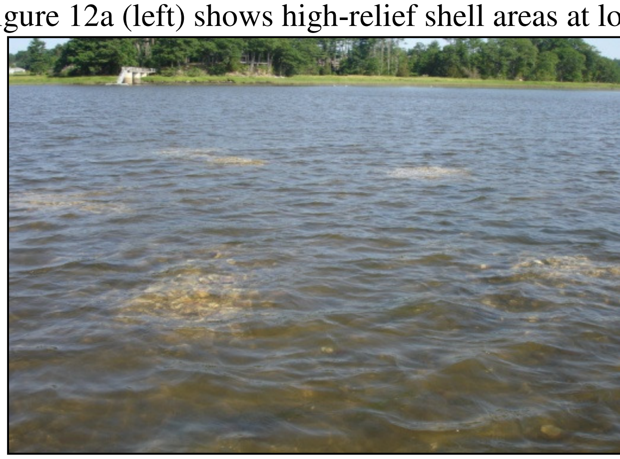
Figure 10. Ray Konisky with spat-on-shell being ferried out to Lamprey Reef

In September, we conducted post-construction monitoring of the reefs. We had acquired a small set of "patent tongs" to use for channel monitoring, but field tests did not produce consistent and efficient samples. We returned to quadrat sampling for annual counts. In the shallow reef areas reached by wading, we used a 0.1 m^2 PVC quadrat tossed on a reef area with shells in the quadrat excavated by hand to a depth of about 3". For the deep channel areas, we worked from a boat with standard oyster tongs to sample the reef. Multiple tong samples were taken until a comparable amount of shell was secured as a sample for spat inspection. All sampled shells were visually inspected for live spat.

Figure 11. Quadrat sampling at Lamprey River Reef in September 2011

Natural spat recruitment on clamshell was assessed using a stratified sampling method. We observed that shell distribution across the reef was more uneven than in previous years, likely due to a change in the size of the feed bag chute. Three categories of shell depth were stratified: high-relief (about 3-4" of shell), low-relief (~1" of shell), and no cover at all. Figure 11 shows sampling from high-relief areas. We did several drifts over the reefs on a minus-tide to estimate the relative amount of each cover category. Coverage of reef area was estimated as 20% high-relief, 40% low-relief, and 40% with no shell cover. We obtained 7 random quadrat samples in high-relief and 13 in low-relief areas for a total of 20 samples. See Figure 12a for an image of other high-relief areas in one section of reef at low tide. Sample results showed that high-relief areas were especially successful at settling spat, with an average of 89/m^2. Low-relief areas were much less dense at 4.5/m^2. From our cover percentages, we estimate a total natural recruitment of 58,180 spat and an overall density of 19.5/m^2 across the two-acre grids. *This result met our restoration objective to recruit 20 spat/m^2 from natural sources*. Figure 12b shows examples of oyster spat settled on clamshell.

Figure 12a (left) shows high-relief shell areas at low tide; 12b is natural oyster spat on clamshell

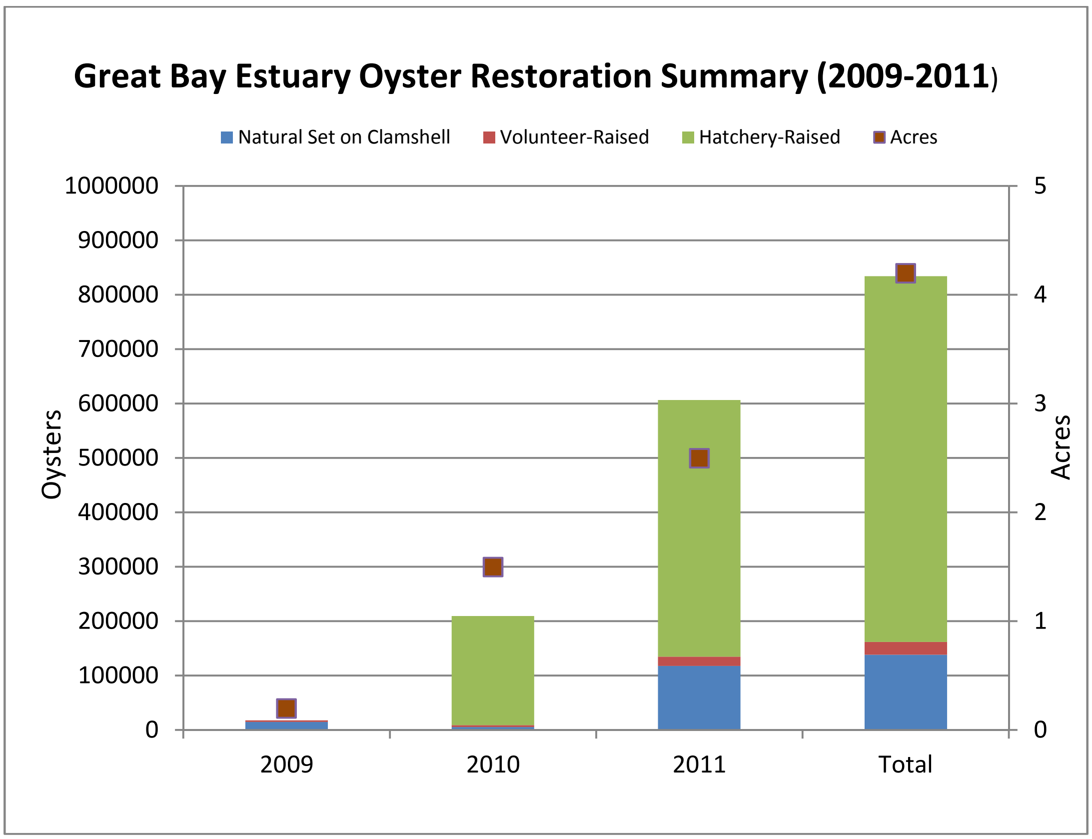


Our live oyster counts for the two-acre Lamprey River reef was an estimated 503,711 spat. In addition, we again worked with an oyster farmer to construct an added 0.5 acre of reef with seeding. In total, our 2011 Lamprey River reefs produced a total standing-stock of 606,637 juvenile oysters, for an average density of about 60/m^2 across the entire 2.5 acre site area. To our knowledge, the work accomplished in 2011 represents the single largest and most successful oyster restoration project ever conducted in the Gulf of Maine, and possibly New England.

Benefits

The work conducted in 2011 contributes greatly to a growing success story of recovering lost populations and ecosystem services in Great Bay Estuary. Our total program oyster restoration results from 2009 to 2011, including the pilot reef, the Wagon Hill reef, and the Lamprey River reefs, has produced 834,326 individual oysters and 4.2 acres of reef restored to the Great Bay Estuary. Figure 13 shows these annual summary results and the outstanding contribution of the PREP-funded work in 2011.

Figure 13. Three-year summary of oysters and acres restored in Great Bay Estuary



In addition to direct recovery of lost oyster reef, other elements of the project showed the community commitment and outreach value of the PREP project. A separate and extremely valuable component of our work is the local oyster shell recycling program. Our expanding operations require more and more oyster shell each year for remote setting but there is no ready supply of oyster shell in any substantial quantity. Anticipating the supply shortage, UNH established a self-service drop-off bin for oyster shell collection in 2006 near the state landing on Adams Point Road in Durham. The bin is still used by locals and an occasional recreational harvester, but it only returns several bushels of shell annually. For our hatchery work to expand, we needed several tons per year. In 2010, one of our partner organizations, Coastal Conservation Association (CCA) took on this big challenge. Together with $10,000 seed funding from Orvis Company, CCA recruited local restaurants and fish markets to collect oyster shells. They developed a network of volunteer drivers, purchased bins, and secured a trailer for pickup and transport. Restaurants and suppliers now participating in the program include Robert's Maine Grill, Jumpin' Jays Fish Café, The Oar House, The Old Salt, Little Bay Oyster Company, Philbrick's Fresh Market, Sanders Fish Market and Surf Restaurant. All shell is delivered to a compost facility operated at UNH Kingman Farm, where it is dried for at least six months. In the spring, the shell is trucked to JEL where a crew of volunteers washes the shell before use in the hatchery tanks. In 2010 and 2011, the CCA program collected about 10 tons of oyster shell and most was used for operations.

We have also earned substantial media coverage for this project. Our program was featured by a film crew from Boston Channel 5 Chronicle for a piece that was televised in January 2011. We were also the cover story of the UNH Alumni magazine in winter 2011. During reef construction, the Associated Press picked up on the Lamprey River reef construction project in June. The reporter's story was run in all three local NH newspapers and many other national news outlets across the US. We also received additional press cover in November 2011 with a front-page story in the New Hampshire Union Leader. TNC maintains links to all media on our public relations NH oyster website at www.nature.org/nhoysters.

Financial Results

Official financial reports documenting grant and match costs will be submitted separately to PREP through TNC and UNH financial administration offices. Table 1 shows how PREP funds provided the leading contribution to the full suite of activities and funding sources for the 2011 oyster restoration program. This program could not have been done without PREP funding and project participants are grateful for this exceedingly high level of support.

Table 1. Estimated oyster restoration project sources and support for 2011 (TNC and UNH)

Sources	**Needs Funded/Supported**	
The Nature Conservancy	Project Mgt, Coordinator, Admin	51416
SCC NH Moose Plates	Project Mgt, Contractual, Supplies, Admin	22119
NOAA Restoration Center	Coordinator, Contractual, Admin	23496
Piscataqua Region Estuaries Partners	Project Mgt, UNH Tech Services, Supplies, Admin	74074
Blount Seafood (in-kind)	Shell (325 total cubic yards @ $39)	9000
Orvis Company (CCA)	Shell Recycling	5000
Volunteer Conservationists (in-kind)	Oyster Production/Outreach (700 total hrs)	9072
Volunteer Workers (in-kind)	Shell Handling (216 total hrs)	1956
		196133